On a Simple Physical Method of illustrating the Principles of Geometrical Optics

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XXVII. *On a Simple Physical Method of illustrating the Principles of Geometrical Optics.* *By* R. M. ARCHER, *A.R.C.Sc., B.Sc. (Lond.)**.

[Plate XXIV.]

THE principles of geometrical optics are frequently illustrated by experiments in which the images of narrow obstacles are obscured by similar obstacles arranged in the line of vision. This method is somewhat tedious and is open to the objection that the path of a shadow is traced rather than that of a beam. The following method is free from these objections, and will be found interesting and convincing †.

The procedure is to allow light from a narrow rectilinear source to pass through a slit and fall upon a flat white surface at almost grazing incidence. In most cases the source may be the straight filament of a glow-lamp, and should be arranged parallel to the slit and not less than about 18 inches from it. Alternatively, a batswing burner with the flame "edge on" to the slit may be employed, but must be screened from draughts by a suitable enclosure.

It will be found easy to obtain upon the white surface a long narrow streak of light with sharp edges; and if a mirror be placed with its plane approximately normal to the surface another streak corresponding to the reflected ray will be seen. Similarly, the path of the beam after its emergence from a glass block or prism may be traced. When it is desired to trace the refracted beam before emergence, a glass tank of the required shape should be filled with water and the internal beam allowed to graze a white surface (*e. g.* that of a glazed tile) supported almost horizontally in the water. Provided, however, the glass block has a transparent base, all that is necessary is to coat the latter with white enamel paint and allow the internal beam

* Read May 8, 1908.

† My thanks are due to Mr. R. S. Bowman, B.Sc., for the valuable assistance he has rendered during the preparation of the photographs.

to strike this at a low angle. If in the above cases of refraction the incident light be bright, emergent beams which have been internally reflected several times will be observed.

Very beautiful effects can be obtained by using many slits and casting the beam from a distant optical lantern upon them. This mode of illumination was adopted in the case of the photographs reproduced (Pl. XXIV.). Perhaps the most striking case to select is that of a narrow concave strip cut from a cylindrical mirror. If this be illuminated by a very wide beam, a general convergent effect will be produced. The broad beam may then be analysed into many narrow ones by interposing a cardboard comb, and the formation of a caustic demonstrated. For this latter purpose it is better to skew the mirror until its main axis is oblique to the incident light. The broad beam may then be used and the skew caustic traced upon the surface by a black crayon. When the comb is interposed all the reflected rays will touch the curve, and the whole reflected set will sweep round it when the comb is given a transverse displacement. The best effects are obtained when the radiant is small, distant, and brilliant. In lecture demonstrations the prism or mirror may be fixed on a sheet of white cardboard attached to a vertical board.

When a divergent pencil is required a broad beam should be cast upon several narrow plane mirrors, and the latter turned until they converge the light upon the back of the slit. For laboratory purposes, however, it is generally sufficient to put the glow-lamp into different positions and trace the successive paths of the single beam.

Cylindrical lenses do not give such good effects as mirrors; but if they are allowed to project through a narrow aperture in the cardboard the results are fairly satisfactory.

Darkening the whole room renders the demonstrations more effective, but for individual work local screening is sufficient.

In conclusion it may be remarked that quantitative results can be obtained of an accuracy comparable with that usually reached in experiments with the ordinary optical bench.

Discussion.

Prof. C. H. Lees expressed his interest in the neatness of the experiments, and said the Author's method of dividing up a beam was a very useful one.

Mr A. Campbell congratulated the Author and remarked that the methods described could be applied to other optical experiments. In using a vibration galvanometer or an oscillograph, an easy way to obtain a curve of the wave-form was to put obliquely in the path of the beam a sheet of white paper and vibrate it.

Dr W. H. Eccles also congratulated the Author upon his paper.

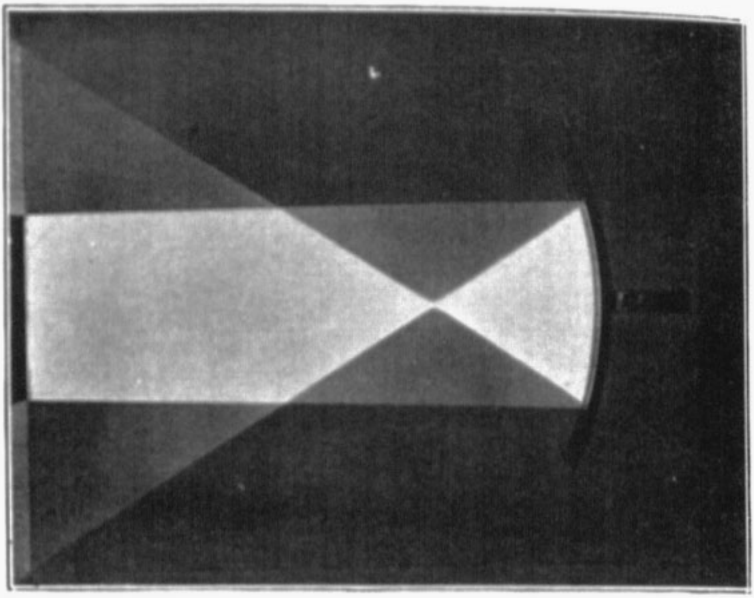
XXVIII. *Note on the Amount of Water in a Cloud formed by Expansion of Moist Air.* By W. B. Morton, *Professor of Natural Philosophy, Queen's College, Belfast* *.

The calculation of the total mass of water condensed, when a volume of air saturated with vapour receives a given sudden expansion, is an important step in Prof. J. J. Thomson's determination of the charge on a gaseous ion †. In conjunction with the size of a single drop, as found from the rate of fall of the cloud, it gives the number of drops in unit volume and so the number of the ions which form the nuclei of the drops. In making the calculation Prof. Thomson, following C. T. R. Wilson, makes the assumption that the air is cooled down to the full extent by the adiabatic expansion before the drops begin to form. Then condensation proceeds and the latent heat liberated warms the air until the density of the remaining vapour is such as to saturate the air at the increased temperature. This process is, of course, irreversible. There is no reason to doubt that it represents closely the actual experimental conditions; but with a view to estimate the amount of error which would be introduced by a small departure from the assumed process, it seems of some interest to calculate, for comparison, the result of the other extreme

* Read June 12, 1908.

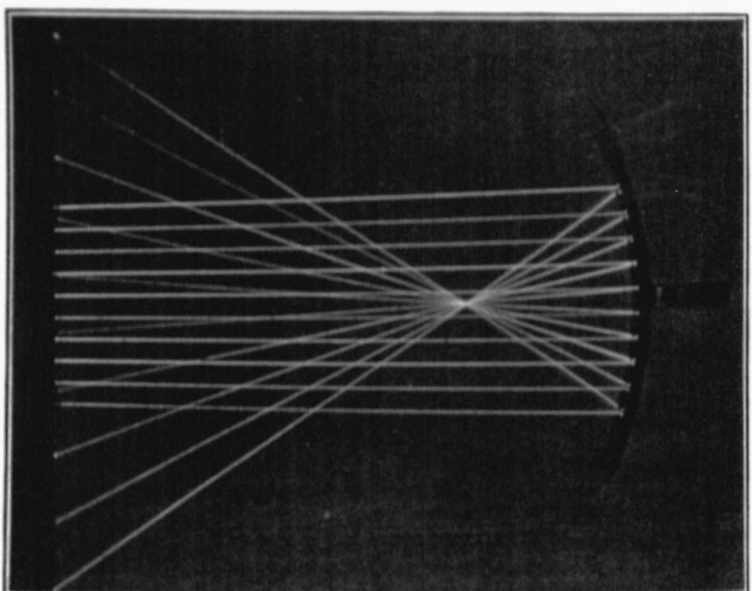
† 'Conduction of Electricity through Gases,' p. 122.

FIG. 1.



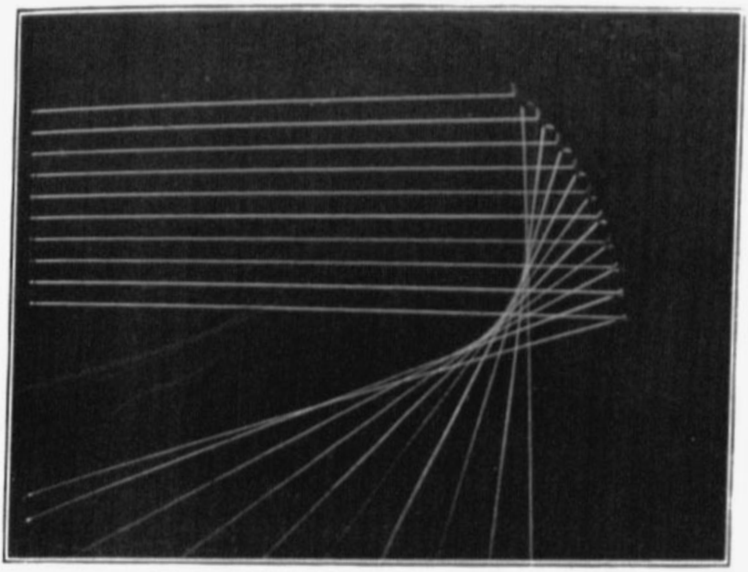
General convergent action of concave (cylindrical) mirror.

FIG. 2.



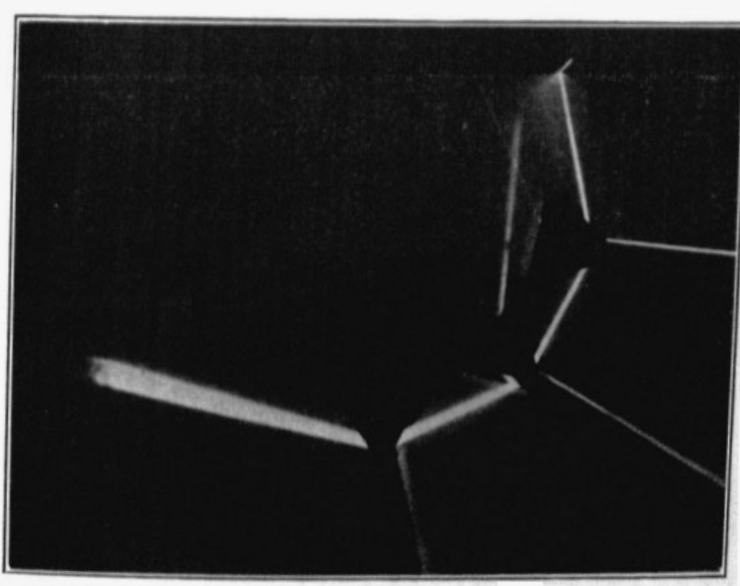
Analysis of fig. 1 into narrow beams.

Fig. 3.



Concave cylindrical mirror. Rays touching caustic curve.

Fig. 4.



Dispersion by train of prisms.